# VEGETATION QUADRATS 1982-83 AND BROAD REGENERATION PATTERNS ON GREAT ISLAND, THREE KINGS ISLANDS, NORTHERN NEW ZEALAND

E.K. CAMERON*, G.T.S. BAYLIS** AND A.E. WRIGHT***

* BOTANY DEPARTMENT, UNIVERSITY OF AUCKLAND, AUCKLAND
** BOTANY DEPARTMENT, UNIVERSITY OF OTAGO, DUNEDIN
*** AUCKLAND INSTITUTE AND MUSEUM, AUCKLAND

*Abstract.* Vegetation quadrats established in 1946 following the removal of goats from Great Island, Three Kings Group, were re-surveyed in 1982 and 1983. New plans of the quadrats are presented, and compared with earlier surveys in 1946, 1951 and 1963. For the two forested quadrats basal area and density figures are presented. A broad discussion of forest regeneration patterns on the island is given.

The three vegetation quadrats established by Turbott in 1946 (Turbott 1948) on Great Island, Three Kings Group (Fig.1) to monitor changes following the removal of goats were remapped in 1951 (Holdsworth 1951) and 1963 (Holdsworth & Baylis 1967). This paper describes them during the Offshore Islands Research Group's expeditions 12-18 December 1982 (when GTSB and AEW studied Quadrat III) and 25 November — 2 December 1983 (when EKC and GTSB mapped Quadrats I and II).

## METHODS

### *Quadrats I & II*

The quadrats were divided into smaller squares with string laid by compass and sighting, much as in the previous two surveys: 400, 2x2 m squares for Quadrat I and 225, 1x1 m squares for Quadrat II (Fig.2). The original stone cairns at each corner of the quadrats were still in place, made easier to find by the aluminium poles of 1963. Plastic boundary markers, also attached by Holdsworth & Baylis in 1963 clarified the boundaries of the quadrats. Even so, there were still minor discrepancies in matching the 1963 and 1983 boundaries.

Presence or absence of vascular plants were recorded for each small square (Figs.3,4), apart from seedlings of woody species (<30 cm tall and with at least one true leaf) which were recorded separately. The position of all woody plants with a diameter at breast height (dbh) ≥2.5 cm, was mapped and their diameters measured. As in previous surveys shrubs and young trees were not mapped. Instead they were recorded as present/absent in the small squares. Apart from *Pyrrosia serpens* epiphytes were absent.


Fig. 1. Location of permanent vegetation quadrats on Great Island, Three Kings Group.

*Quadrat III*

By 1982, the vegetation over most of this quadrat had become so dense that the laying out of a grid square would have caused considerable damage. It was decided to mark the boundaries of the quadrat with tape. The quadrat was then divided into visually distinct areas based on height and species composition and these areas mapped. Lists were made of all species present in each area, and each species was assigned a cover value, *viz.* 1 : < 1%; 2 : 1 < 10%; 3 : 10 < 30%; 4 : > 30%. As in earlier surveys, kanuka (*Kunzea ericoides*) was divided into the apparently genetically distinct types (erect and trailing) referred to by Holdsworth & Baylis (1967).

## RESULTS AND DISCUSSION

The position of a few canopy trees mapped on the previous survey did not quite correspond with our results for Quadrats I & II. The ground, which is on a gradual slope, also appears to have moved slightly as the exact dimensions of the quadrats were

Fig. 2. Stringing out Quadrat II into 1x1 m squares on 27 November 1983.

not true. For example, Quadrat I starting with the western boundary and proceeding clockwise, measured 40.0 x 40.0 x 40.1 x 39.5 m; Quadrat II starting with the north-west side, 15.0 x 15.7 x 15.2 x 15.2 m.

*Quadrat I*

Of the four seedlings marked in 1946, only two survive today. Both are wharangi (*Melicope ternata*) (Table 1). Their growth over 37 years has been very slow. The overall number of species present on the quadrat has slightly decreased since 1963 (Table 2).

*Canopy* (Fig.3). The canopy is closed and rather even at 8-12 m in height, apart from the few emergent mangeao (*Litsea calicaris*) and a rather narrow gap running east-west, situated north-east of the centre of the quadrat.

Table 1. Quadrat I. Height of the four marked seedlings[1].

| Peg no. | Species | 1946 | 1948 | 1951 | 1983 height | 1983 dbh[2] |
|---|---|---|---|---|---|---|
| 1 | *Melicope ternata* | 15.2[3] | 86.4 | 144.8 | 500.0 | 6.0 |
| 2 | *Melicytus ramiflorus* | 2.5 | 40.6 | — | — | — |
| 3 | *Melicope ternata* | 10.2 | 76.2 | 88.9 | 180.0 | 2.0 |
| 4 | *Passiflora tetrandra* | 5.0 | 61.0 | — | — | — |

[1] Refer to Turbott (1948) and Holdsworth (1951).
[2] Diameter at breast height (1.4 m).
[3] cm.

Table 2. Quadrats I — III. Number of species of vascular plants per quadrat.

| Quadrat | 1946 | 1951 | 1963 | 1983 |
|---|---|---|---|---|
| I | 23 | 25 | 37 | 33 |
| II | 18 | 18 | 21 | 23 |
| III | 13 | 21 | 32 | 35* |

* Recorded in 1982.

Mahoe (*Melicytus ramiflorus*) is the most frequent woody plant present being two and a half times more frequent than the next common species, which is kanuka (Table 3). However mahoe are relatively small-trunked contributing only 18% to the total basal area compared with 48% by kanuka (Table 4). Many of the trees are multi-stemmed: 27% of mahoe, 14% of kanuka, but by far the most frequently branched is the Three Kings' cabbage tree (*Cordyline kaspar*) (hereinafter referred to as cabbage tree) at 67%. Ten kanuka present in the canopy in 1962 have died and only five new kanuka have replaced them (Table 5). Nine mahoe died during the same period, but these have been replaced by 125 individuals. Puka (*Meryta sinclairii*) has doubled its frequency in the canopy during this 20 year period and the total number of canopy plants has doubled since 1963 (Table 3). However, there is less change in the basal area since large kanuka have been replaced with smaller and more numerous mahoe.

*Coprosma macrocarpa* and parapara (*Pisonia brunoniana*) have reached the canopy for the first time (Table 3). The basal areas of all the species recorded in the canopy in 1963, excluding the original canopy plants, showed small increases (Table 4). Some of the "new" cabbage trees are doubtless suckers from old plants which have died down.

Table 3. Quadrats I & II. Density[1] of canopy plants[2].

| | Quadrat I | | | | Quadrat II | | | |
|---|---|---|---|---|---|---|---|---|
| | 1946 | 1951 | 1963 | 1983 | 1946 | 1951 | 1963 | 1983 |
| *Brachyglottis arborescens* | | | 6.3 | 12.5 | | | | |
| *Coprosma macrocarpa* | | | | 37.5 | | | | 133.3 |
| *Cordyline kaspar* | 181.3 | 212.5 | 175.0 | 187.5 | 44.4 | 44.4 | 1066.6 | 622.2 |
| *Entelea arborescens* | | | 125.0 | 193.8 | | | | |
| *Geniostoma rupestre* | | | 12.5 | 181.3 | | | | 44.4 |
| *Kunzea ericoides* | 312.5 | 212.5 | 387.5 | 356.3 | 2044.2 | 888.8 | 933.2 | 977.8 |
| *Litsea calicaris* | 25.0 | 25.0 | 31.3 | 81.3 | | | | |
| *Melicope ternata* | 31.3 | 31.3 | 56.3 | 131.3 | | | | |
| *Melicytus ramiflorus* | 6.3 | 6.3 | 512.5 | 1231.3 | | | 44.4 | 88.9 |
| *Meryta sinclairii* | | | 93.8 | 193.8 | | | 400.0 | 311.1 |
| *Pisonia brunoniana* | | | | 81.3 | | | | |
| *Pittosporum fairchildii* | | 6.3 | 6.3 | 68.8 | | | | |
| *Streblus smithii* | | 12.5 | 18.8 | 87.5 | | | 44.4 | 44.4 |
| Totals | 556 | 506 | 1425 | 2844 | 2089 | 933 | 2489 | 2222 |

[1] Numbers of living individual plants per hectare. [2] Diameter at breast height ⩾2.5 cm.

Table 4. Quadrats I & II. Basal area[1] of canopy plants[2].

| | Only canopy plants first recorded in 1963 | | | | Total canopy plants | |
|---|---|---|---|---|---|---|
| | Quadrat I | | Quadrat II | | Quadrat I | Quadrat II |
| | 1963[3] | 1983 | 1963[3] | 1983 | 1983 | 1983 |
| *Brachyglottis arborescens* | 0.17 (3) | 0.51 (4) | | | 0.52 (1) | |
| *Coprosma macrocarpa* | | | | | 0.05 (<1) | 0.09 (<1) |
| *Codyline kaspar* | | | 1.58 (38) | 1.78 (18) | 5.28 (12) | 2.49 (6) |
| *Entelea arborescens* | 0.84 (14) | 0.35 (3) | | | 1.04 (2) | |
| *Geniostoma rupestre* | 0.11 (2) | | | | 0.61 (1) | 0.04 (<1) |
| *Kunzea ericoides* | 2.18 (37) | 5.69 (43) | 1.36 (33) | 5.11 (52) | 21.23 (48) | 35.07 (86) |
| *Litsea calicaris* | | | | | 4.08 (9) | |
| *Melicope ternata* | 0.13 (2) | 0.13 (1) | | | 0.39 (1) | |
| *Melicytus ramiflorus* | 1.68 (29) | 4.72 (35) | 0.35 (9) | 1.47 (15) | 7.84 (18) | 1.47 (4) |
| *Meryta sinclairii* | 0.75 (13) | 1.91 (14) | 0.80 (20) | 1.42 (15) | 2.73 (6) | 1.42 (4) |
| *Pisonia brunoniana* | | | | | 0.13 (<1) | |
| *Pittosporum fairchildii* | | | | | 0.06 (<1) | |
| *Streblus smithii* | 0.04 (<1) | 0.05 (<1) | | 0.04 (<1) | 0.19 (<1) | 0.04 (<1) |
| Totals | 5.9 (100) | 13.4 (100) | 4.1 (100) | 9.8 (100) | 44.1 (100) | 40.6 (100) |

[1] Area of stem across section at breast height (1.4 m) $m^2$ per hectare.
[2] Diameter at breast height ⩾2.5 cm.
[3] Adapted from Table 3, Holdsworth & Baylis (1967).

Table 5. Quadrats I & II. Numbers of canopy trees*[1].

| | Quadrat I | | | | | | | Quadrat II | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1946 | 1951 | 1963 | | 1983 | | | 1946 | 1951 | 1963 | | 1983 | | |
| *Brachyglottis arborescens* | | | | (1) | | (1) | [1] | | | | | | | |
| *Coprosma macrocarpa* | | | | | | | [5] | | | | | | | [3] |
| *Cordyline kaspar* | 29 | 34 | 28 | — | 22 | — | [8] | 1 | 1 | 1 | (23) | 1 | (12) | [1] |
| *Entelea arborescens* | | | | (20) | | (6) | [25] | | | | | | | |
| *Geniostoma rupestre* | | | | (2)[2] | | | [29] | | | | | | | [1] |
| *Kunzea ericoides* | 50 | 34 | 23 | (39) | 20 | (32) | [5] | 46 | 20 | 15[3] | (6) | 15 | (6) | [1] |
| *Litsea calicaris* | 4 | 4 | 4 | (1) | 4 | — | [9] | | | | | | | |
| *Melicope ternata* | 5 | 5 | 4 | (5) | 1 | (2) | [18] | | | | | | | |
| *Melicytus ramiflorus* | 1 | 1 | 1 | (81) | 1 | (72) | [125] | | | | (1) | | (2)[4] | — |
| *Meryta sinclairii* | | | | (15) | | (13) | [18] | | | | (9) | | (7) | — |
| *Pisonia brunoniana* | | | | | | | [13] | | | | | | | |
| *Pittosporum fairchildii* | | 1 | 1 | — | | | [11] | | | | | | | |
| *Streblus smithii* | | 2 | 1 | (2) | 1 | (2) | [11] | | | | (1) | | (1) | — |
| Totals | 89 | 81 | 62 | (166) | 49 | (128) | [278] | 47 | 21 | 16 | (40) | 16 | (28) | [6] |

* Survivors of 1946 canopy not bracketed; figures in parenthesis first recorded in canopy in 1963; figures in square brackets first recorded in canopy in 1983.

[1] Plants with a diameter at breast height ≥2.5 cm.
[2] Originally recorded as 3, but only 2 shown on 1963 quadrat.
[3] Originally recorded as 13, but 15 shown on 1963 quadrat.
[4] Originally recorded as 1, but another recorded as a different species in 1963, see Appendix I.

*Shrubs* (Appendix 1). Since the quadrat was established the seven ngaio (*Myoporum laetum*) shrubs have decreased in number and by 1983 all were dead (Table 6). There have been no new species in the shrub layer but the abundance of species has changed. Because the shrubs in 1983 were only recorded as present/absent in the smaller squares, changes cannot be quantified, but general trends are evident. Mahoe (especially), mangeao and kanuka have decreased through ascending into the canopy, and there are now no kanuka shrubs. All other species have increased, especially *Coprosma macrocarpa*, parapara and hangehange (*Geniostoma rupestre*).

*Lianes* (Fig.3). The three liane species previously recorded are still present. On the present/absent basis in the 2x2 m squares the number of rooted plants of *Clematis paniculata* has only slightly increased, *Muehlenbeckia complexa* (erroneously recorded as *M. australis* on the 1963 Quadrat I canopy diagram, Holdsworth & Baylis 1967) shows a 35% increase and *Passiflora tetrandra* a 70% increase. Because these plants are capable of rooting at their nodes this increase is not necessarily an increase in the number of individuals.

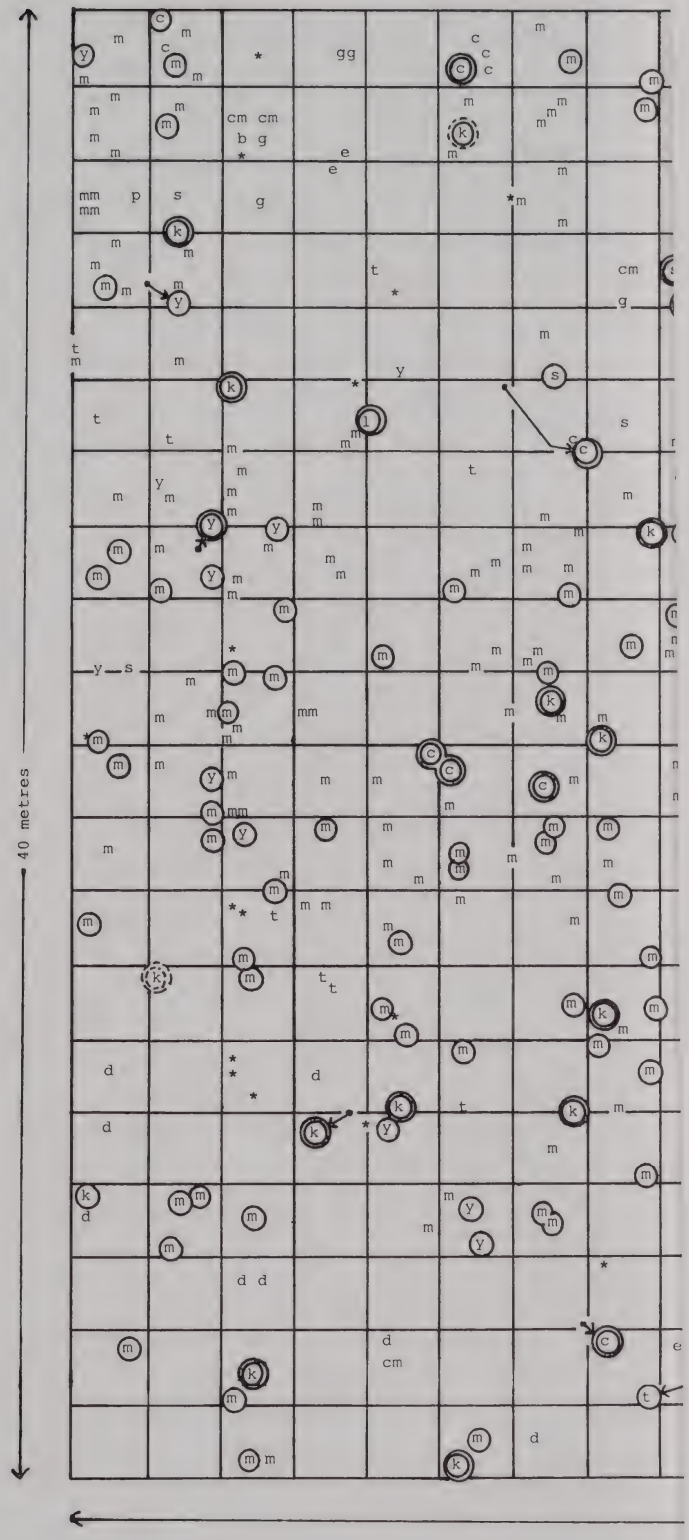


Fig. 3. Quadrat I, 1983. Plants with ⩾2.5 cm dbl
since 1963. No outline indicates the plant was r
th

— also recorded in 1963.

— original canopy tree.

b. *Brachyglottis arborescens*. c. *Cordyline kasp*
*arborescens*. g. *Geniostoma rupestre*. k. *Kunz*
s. *Streblus smithii*. t

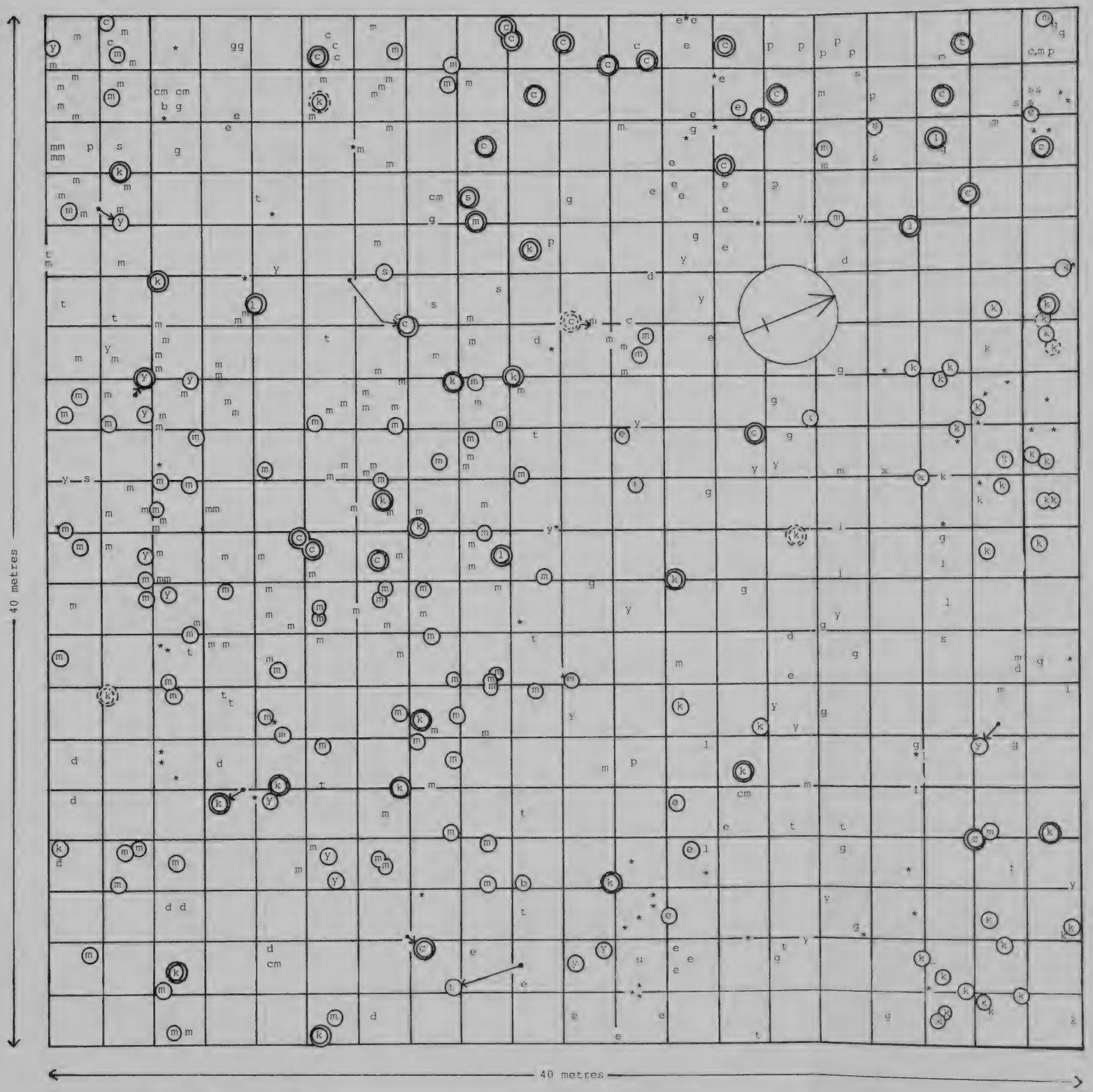


Fig. 3. Quadrat I, 1983. Plants with ⩾2.5 cm dbh, excluding lianes. Stars indicate sites of trees that have disappeared since 1963. No outline indicates the plant was not recorded in the canopy in 1963. Arrows reconcile positions with those on the 1963 map.

— also recorded in 1963.

— dead standing trees.

— original canopy tree.

— wrongly shown as dead in 1963.

b. *Brachyglottis arborescens*. c. *Cordyline kaspar*. cm. *Coprosma macrocarpa*. d. *Pisonia brunoniana*. e. *Entelea arborescens*. g. *Geniostoma rupestre*. k. *Kunzea ericoides*. m. *Melicytus ramiflorus*. p. *Pittosporum fairchildii*. s. *Streblus smithii*. t. *Melicope ternata*. y. *Meryta sinclairii*.

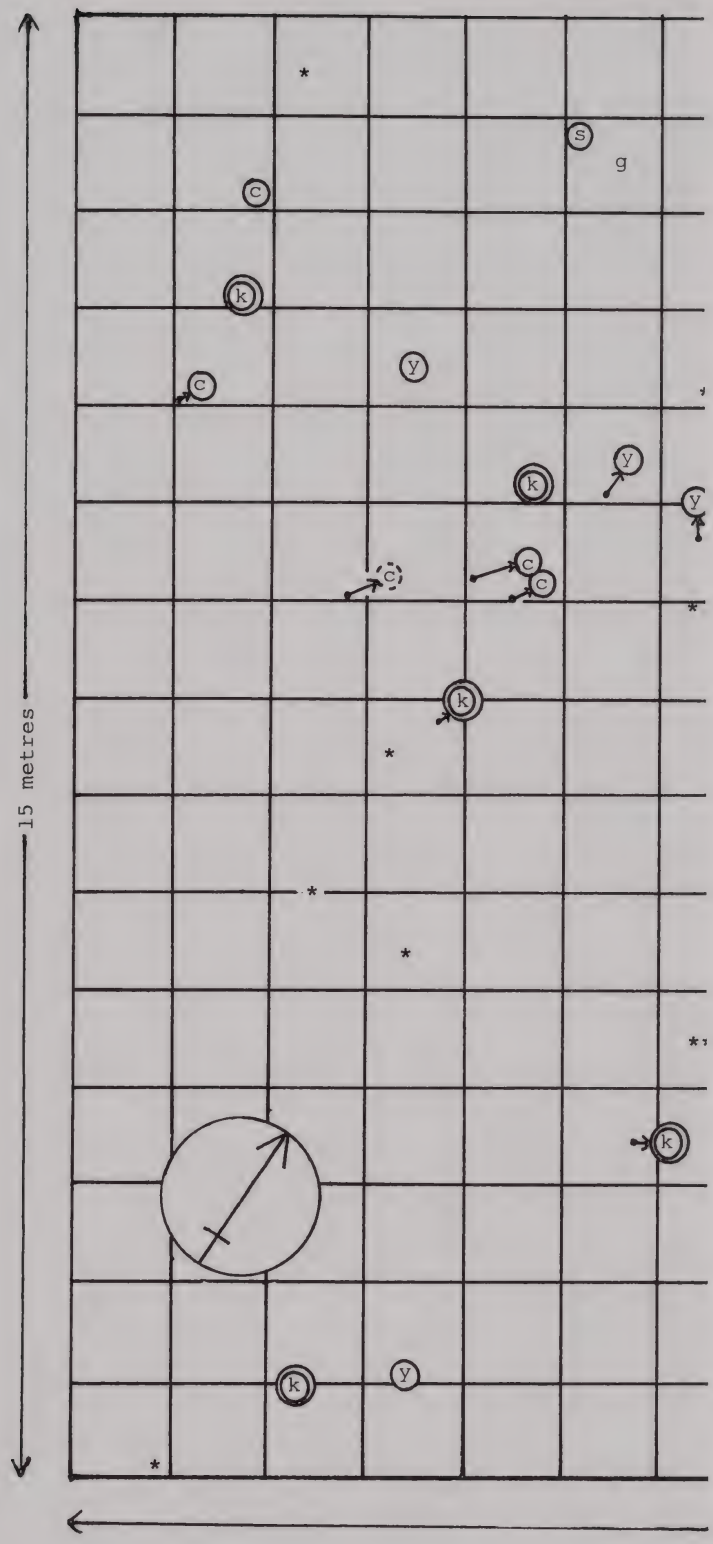


Fig. 4. Quadrat II, 1983. Plants with ⩾2.5 cm
disappeared since 1963. No outline indicates the pl

— also recorded in 1963.

— also recorded in 1951.

c. *Cordyline kaspar*. cm. *Coprosma macrocarp*
*ramiflorus*. s. *Stre*

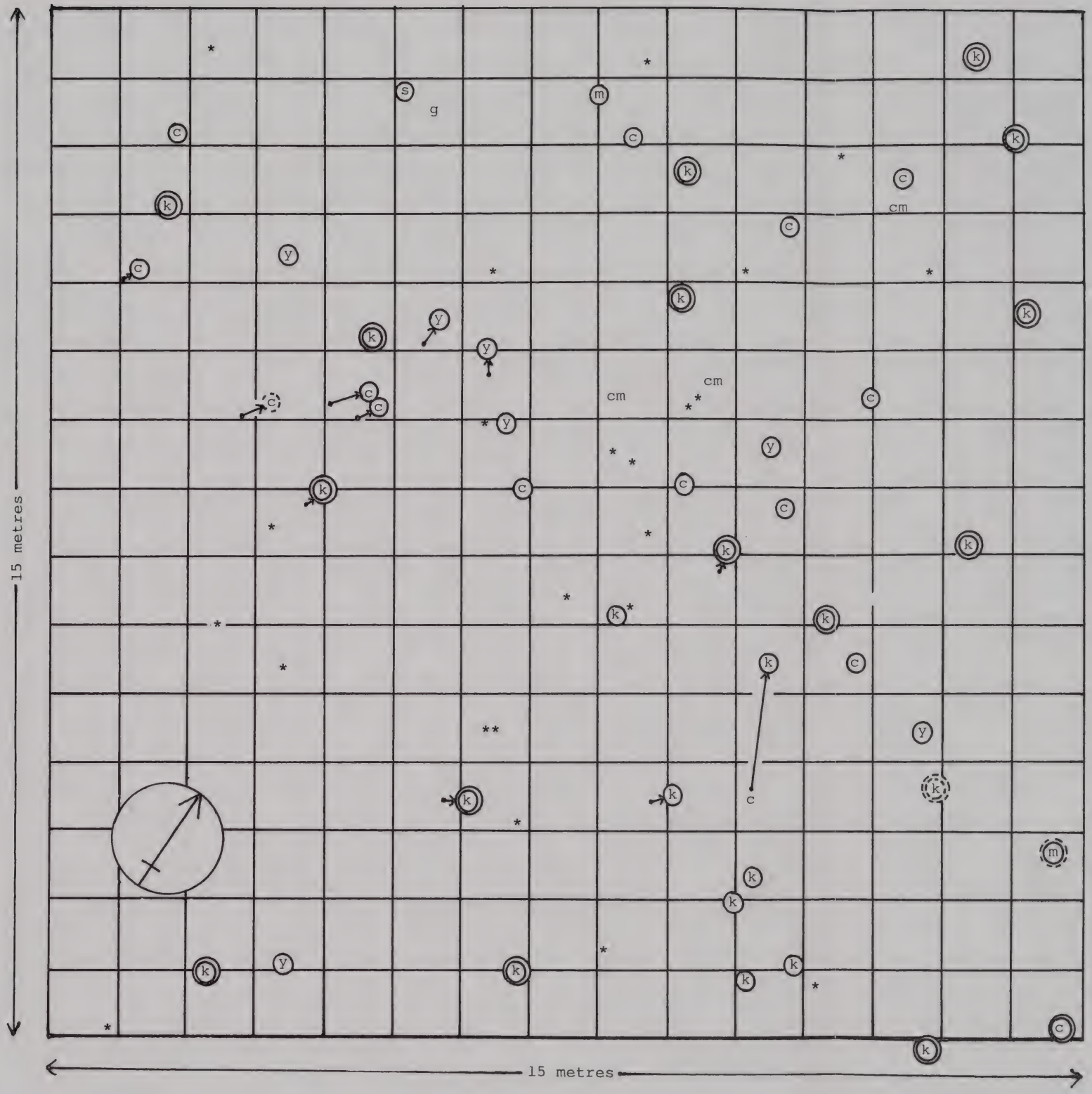


Fig. 4. Quadrat II, 1983. Plants with ⩾2.5 cm dbh, excluding lianes. Stars indicate sites of trees that have disappeared since 1963. No outline indicates the plant is new to the site. Arrows reconcile positions with those on the 1963 map.

— also recorded in 1963.

— also recorded in 1951.

— dead standing trees.

— recorded as a different species in 1963.

c. *Cordyline kaspar*. cm. *Coprosma macrocarpa*. g. *Geniostoma rupestre*. k. *Kunzea ericoides*. m. *Melicytus ramiflorus*. s. *Streblus smithii*. y. *Meryta sinclairii*.

*Herbs* (Appendix 1). An increase in diversity of herbs was recorded in 1963, but the number has now declined from 19 to 16 species, though four are new (Table 6). There has been a further reduction in the area covered by the sedges (*Carex* spp.) and *Pratia physaloides*. The fern *Doodia media* has slightly increased in abundance.

*Quadrat II*

There has been a net increase of two species since 1963 (Table 2), six gains and four losses (Table 6). Over the life of the quadrat, 17 species have come and gone (Table 6).

*Canopy* (Fig.4). Apart from the northern corner where there are large gaps, the canopy is rather even and closed at 8-10 m in height. The most numerous species is kanuka with cabbage tree second (Tables 3,5). Kanuka is the only species with significant basal area (Table 4). The canopy has always been dominated by kanuka, even when cabbage trees were more numerous, as cabbage trees have relatively narrow heads. Mahoe and parapara have not increased in number, unlike the situation on Quadrat I. The grand total of canopy plants has slightly decreased since 1963 (Table 3).

None of the 21 kanuka recorded in the canopy in 1963 have died and there has been one addition (Table 5). Cabbage trees on the other hand have almost halved in number during this period, but some rootstocks may remain alive. *Coprosma macrocarpa* and hangehange have now reached the canopy. The basal areas of the species recorded in the canopy for the first time in 1963 show small increases, except kanuka and mahoe which show approximately 4-fold increases (Table 4).

*Shrubs* (Appendix 2). The single ngaio recorded in 1951 was missing by 1963, and now the single wharangi recorded in 1946, 1951 and 1963 has also disappeared (Table 6). *Coprosma macrocarpa* is recorded on the quadrat for the first time in low numbers. Compared with 1963 figures there is little change in abundance of *Coprosma rhamnoides*, by far the most abundant shrub. Mahoe, *Streblus smithii* and parapara are present in very low numbers, as in 1963, but parapara is also represented by 20 seedlings. Cabbage trees and kanuka have decreased; mangeao, *Pittosporum fairchildii* and hangehange have increased, the latter markedly.

*Lianes* (Appendix 2). The two lianes recorded in 1963 are still present in low numbers. *Passiflora* covers more than twice as many squares as *Clematis*.

*Herbs* (Appendix 2). In Quadrat I, 53 squares (2x2 m) are bare of herbs but in Quadrat II ground cover remains dense (Fig.2) with only one empty square (1x1 m). Over the lifetime of the quadrat, 16 herb species have come and gone; five have been gained and four lost since 1963 (Table 6).

*Quadrats I and II*

After an initial increase in response to the cessation of goat browsing in 1946 the number of vascular plant species per quadrat has remained roughly the same since

Table 6. Quadrats I — III. Numbers of rooted plants, excluding canopy trees[1]*.

| Species[3] | Quadrat I | | | | Quadrat II | | | | Quadrat III | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1946 | 1951 | 1963 | 1983[4] | 1946 | 1951 | 1963 | 1983[4] | 1946 | 1951 | 1963 | 1982 |
| *Adiantum hispidulum* | | | P† | 1.8 | | | | 0.9 | | | 12 | P |
| *Aira caryophyllea* | | | | | | | | | | P | 33 | P |
| *A. praecox* | | | | | P | | | | | P | 2 | |
| *Arthropodium cirratum* | | | | | | 1 | P | 0.4 | | | | |
| *Asplenium oblongifolium* (*A. lucidum*) | | | P[5] | 5.8 | | | P | 1.8 | | | | P |
| *Brachyglottis arborescens* | | 2 | | 0.5 | | | | | | | | |
| *Bromus willdenowii* (*B. catharticus*) | | | P | | | | | | | | | |
| *Carex breviculmis* | | | | | | | | | | P | 42 | P |
| *C. elingamita* | | | | 1.0 | | | | | | | | |
| *C. testacea* | P | P | P | 26.3 | P | P | P | 92.9 | P | P | 97 | P |
| *C. virgata* | P | P | P | 1.8 | P | | | | | | | |
| *Centella uniflora* (*C. asiatica*) | P | | P | | P | | | | P | P | 39 | P |
| *Cerastium glomeratum* | | | | | | | | | | | | P |
| *Chloris truncata* | | | | | | | | | | | 2 | |
| *Cirsium vulgare* | | | | | | | | | | | 5 | |
| *Clematis paniculata* | P | P | P | 2.0 | | | P | 2.2 | | | | |
| *Conyza floribunda* (*Erigeron canadensis*) | | P | P | | | 30 | | | | P | 6 | P |
| *Coprosma macrocarpa* | | | | 4.3 | | | | 5.3(9/12)[2] | | | | |
| *C. repens* | | | 2 | | | | | | | | | |
| *C. rhamnoides* | 9 | 27 | 30 | 6.5 | P | 75 | 166 | 50.7 | | | 89 | P |
| *Cordyline kaspar* | | 7 | 9 | 3.5 | | 17 | 5 | 1.1(1/2) | | | P | |
| *Cotula australis* | | | | | | | | | | P | | |
| *Davallia tasmanii* | | | | | | 1 | | | | | 3 | P |
| *Deyeuxia avenoides* | | | | | | | | | | | | P |
| *D. billardieri* | | | | | | | | | | | | P |
| *Dianella nigra* (*D. intermedia*) | | P | | | | 11 | P | | | | 3 | |
| *Dichelachne* (*Deyeuxia*) *crinita* | | | P | | | | | | P | P | 83 | P |
| *Dichondra repens* | P | | | 0.3 | P | | | | P | P | | |
| *Doodia media* | P | | P | 26.5 | P | P | P | 72.4 | P | P | 50 | P |
| *Echinopogon ovatus* | P | P | P | | P | | | | | | 6 | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Elymus multiflorus* (*Agropyron kirkii*) | | | | | | | | | | | 32 | |
| *E. rectisetus* | | | | | | | | | | | | P |
| *Entelea arborescens* | | 3 | 8 | 3.5(1/14) | | | | | | | | |
| *Genioistoma rupestre* (*G. ligustrifolium*) | | 3 | 17 | 17.8 | | | 1 | 21.8(17/48) | | | | P |
| *Geranium solanderi* (*G. dissectum*) | | | P | | | | | | | | | |
| *Gnaphalium audax* | | | | | | | | | | | | P |
| *G. gynocephalum* | | | | | | | | | P | | | |
| *G. spicatum* | | | | | | | | | | | | P |
| *G.* sp. (*G.collinum*)[6] | P | | | | P | | | | | P | 71 | |
| *Gonocarpus incanus* (*Haloragis procumbens*) | | | | | | | | | | | | P |
| *Haloragis erecta* | | P | P | | P | 17 | | | | | 2 | |
| *Hydrocotyle moschata* | | | | | | | | | | | | P |
| *H. novae-zelandiae* | | | | | | | | 0.4 | P | P | | |
| *Hypochaeris radicata* | | | | | | | | | | P | 96 | P |
| *Kunzea* (*Leptospermum*) *ericoides* | 43 | 73 | 7 | | P | 12 | 7 | 2.2(3/5) | P | P | P | P |
| *Litsea calicaris* | | 52 | 75 | 6.5(5/26) | | 4 | 2 | 8.4(15/19) | | | | |
| *Leucopogon fasciculatus* | | | | | | | | | | | | P |
| *L.* (*Cyathodes*) *fraseri* | | | | | | | | | | | 17 | P |
| *Lobelia anceps* | | | | | P | | | | | | | P |
| *Melicope ternata* | 15 | 51 | 39 | 5.3(1/21) | 1 | 1 | 1 | | | | P | |
| *Melicytus ramiflorus* | | 238 | 210 | 5.5(2/22) | | 2 | | 0.9(1/2) | | | | |
| *Meryta sinclairii* | | 15 | 16 | 10.8(15/43) | | 8 | 3 | 10.7(20/24) | | | | |
| *Microlaena stipoides* | | | P | 0.3 | | | | 2.7 | | | 1 | P |
| *Muehlenbeckia complexa*[7] | | *c*.5 | P | 13.8 | | | | | | | | |
| *Myoporum laetum* | 7 | 5 | 2 | | | 1 | | | | | | |
| *Oplismenus imbecillis* (*O. undulatifolius*) | P | P | P | 14.3 | P | P | | 2.2 | P | | 12 | |
| *Oxalis exilis* (*O. corniculata*) | P | | | | P | | | | P | P | | |
| *Paspalum dilatatum* | | | | | | | | | | | | P |
| *Passiflora* (*Tetrapathaea*) *tetrandra* | P | P | P | 25.8 | | P | P | 5.3 | | | | |

Table 6. Quadrats I — III continued.

| Species[3] | Quadrat I | | | | Quadrat II | | | | Quadrat III | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1946 | 1951 | 1963 | 1983[4] | 1946 | 1951 | 1963 | 1983[4] | 1946 | 1951 | 1963 | 1982 |
| *Peperomia urvilleana* | | | | 0.8 | | | | | | | | |
| *Phormium tenax* | | | | | | | | | | | 1 | P |
| *Phymatosorus diversifolius* | | | | 0.8 | | | | | | | | |
| *Physalis peruviana* | | | P | | | | | | | | | |
| *Pisonia* (*Hiemerliodendron*) *brunoniana* | | | 3 | 4.3(4/17) | | | | | | | | |
| *Pittosporum fairchildii* | 1 | 4 | 16 | 11.8(1/47) | | | 2 | 15.1(29/34) | | | | |
| *Poa anceps* | | | | | | | P | | | | | |
| *P. pusilla* | | | | | | | | 0.4 | | | | |
| *Pratia* (*Colensoa*) *physaloides* | P | P | P | 15.8 | | | P | 1.8 | | | | |
| *Pteris comans* | P | P | P | 14.5 | | | P | | | | | |
| *P macilenta* | | | | | | | | | | | 1 | |
| *P. tremula* | | | P | 0.8 | | | | | | | | |
| *Pyrrosia serpens* | | | | 1.5 | | | | 0.4 | | | | |
| *Rytidosperma biannulare* | | | | | | | | | | | | P |
| *R. penicillatum* | | | | | | | | | | | | P |
| *R. racemosum* | | | | | | | | | | | | P |
| *R.* sp. or spp. (*Danthonia semianularis*) | | | | | | | | | P | P | 89 | |
| *Scirpus nodosus* | P | | | | P | | P | | P | P | 123 | P |
| *Senecio glomeratus* | | | | | | | | | | | | P |
| *Sicyos angulata* | | | P | 0.3 | | | | | | | | |
| *Sonchus oleraceus* | | | | | | | | | | P | | |
| *Streblus* (*Paratrophis*) *smithii*[8] | 1 | 5 | 46 | 19.8(1/78) | | 3 | | 5.3(11/12) | | | | |
| *Thelymitra longifolia* | | | | | | | | | | | 1 | P |
| *Vulpia bromoides* (*V. dertonensis*) | | | | | | | | | | P | 31 | P |
| *Wahlenbergia gracilis* | | | | | P | | | | | P | 11 | |
| *Zoysia planifolia* (*Zoisia matrella*) | | | | | | | | | P | P | | |
| Species total | 20 | 25 | 36 | 32 | 17 | 18 | 19 | 23 | 13 | 21 | 32 | 35 |

* In 1983 all potentially woody species of Quadrats I and II exceeded 30 cm in height except for seedlings shown in parenthesis[2].

† Species present.

[1] Plants with a diameter at breast height (dbh) $\geqslant$ 2.5 cm.

[2] Expressed as number of squares with seedlings only, over total number of squares for the species (dbh $<$ 2.5 cm).

[3] Where different names were used in previous quadrat publications, the earlier name is given in parenthesis. Most are taxonomic changes, a few are mistakes in identity.

[4] The 1983 figures are expressed as a frequency (% of squares in which the species is present) based on presence or absence in 400, 2x2m squares for Quadrat I; and 225, 1x1 m squares for Quadrat II. Note the frequencies of Quadrats I and II are not comparable because the divisions are different sizes.

[5] Recorded as *A. obtusatum*, by mistake? However, there is a 1946 Turbott specimen of *A. obtusatum* (AK 22904) collected close to sea level on Great Island.

[6] Specimens at AK of *G. collinum* collected in 1945/46 from forest and scrub on Great Island have been redetermined as *G. delicatum* by D.G. Drury.

[7] *Muehlenbeckia australis* recorded on 1963 Quadrat I canopy diagram (Holdsworth & Baylis 1967) is *M. complexa*.

[8] Suckers freely, making individuals difficult to identify.

1963 (Table 2). Although the abundance of each species varies greatly over time (Table 3), there has been no marked change in species composition. Even though kanuka is outnumbered by another species (mahoe) in the canopy of Quadrat I (Table 3) and is now failing to reproduce itself (Table 6), it will continue to be an important constituent of the canopy for some time because of its longevity of 80-150-(250) years (Burrows 1973).

The regeneration of Quadrat II is similar to Quadrat I but is many years behind, possibly because of the denser herb cover (Fig. 2) which makes it difficult for potential canopy seedlings to establish. This thicker ground cover may account for the decrease in the density of canopy plants since 1963 in Quadrat II and the marked increase during the same period for Quadrat I (Table 3). This difference is possibly because Quadrat I is more of a gully forest than the drier sited Quadrat II.

Although there are no published figures of basal area and denisty for similar vegetation to Quadrats I and II there are some records for coastal, North I, seral forests (Table 7). The Kapiti I manuka basal area figures (Esler 1967) are much lower and their corresponding density is much higher indicating an earlier seral stage than the Great I situation, i.e. abundant small stems with an absence of large stems. The same statistics for Hen I (D.J. Court 1978; A.J. Court 1985) are intermediate between Kapiti I manuka and Great I Quadrat vegetation. The single very high basal area result (83 $m^2$/ha) from Leigh (Ogden 1983) is consistent with what Ogden (1983) found for other kauri forests.

*Quadrat III*

The vegetation was divided into eight visually distinct areas which are mapped out in Fig.5. Appendix 3 lists the species present in each of these areas together with an assessment of their cover value and the height range of the vegetation within the area.

Since 1946, a total of 56 species have been recorded in the quadrat (Table 6), of which 17 were added in 1982. Three of these are notable new records in that they indicate maturation of the plant communites. The most important is mingimingi (*Leucopogon fasciculatus*) which was present in four of the eight areas mapped, albeit in low numbers. It is likely to become the second most important constituent of the future shrub layer (after *Coprosma rhamnoides*) beneath the kanuka canopy. The other two are *Asplenium oblongifolium* and hangehange. Both are present in very small numbers in only one of the eight areas in the quadrat, and may not yet be permanent constituents.

While 17 new records were made, 21 previously recorded species were not found in 1982 (Table 6). Again, three of species lost were indicative of maturation of the plant cover and should return. The species with the greatest potential was wharangi, an important plant in Quadrat I. Cabbage tree which can also be expected to form a notable part of future plant communities on this site, disappeared in the interval between 1963 and 1982. Holdsworth & Baylis (1967) noted that both these elements "may initiate a radical change in this part of the island" although they were "battered isolated specimens".

Table 7. Comparison between Great Island quadrats (I and II) and other North Island seral coastal forests, in terms of basal area and density.

| Site | Method & area sampled ($m^2$) | Dominant species[1] | Basal Area ($m^2$/ha) | Density (stems/ha) | Density (no./ha) | DBH (cm) | Altitude a.s.l. (m) | Canopy height (m) |
|---|---|---|---|---|---|---|---|---|
| Great I | Plot 1x(15x15) &1x(40x40) | Kanuka/mahoe/ Cor kas | 44.1&40.6 37.0&36.8 | 2853&4250 1156&1244 | 2222&2844 875&1020 | ⩾2.5 ⩾10 | 100 | 8-12 |
| Kapiti I (Esler 1967) | PCQ[2] ⩾40 points | Lep sco/Pse arb/ kanuka | 18.4&24.6 | 3996&7769 | — | ⩾10 | 200&350 | 5 |
| | | kanuka/Ole ran/ Pse arb | — | 8026 | — | ⩾2.5 | 230 | 10 |
| | | Ole ran/Hed arb/ mahoe/Pse arb | 41.1 | 1433 | — | ⩾10 | 455 | 8 |
| | | Dys spe/Bei taw/ Hed arb/mahoe | 49.4 | 1779 | — | ⩾10 | 183 | 12 |
| Leigh (Ogden 1983) | PCQ *c.* 25 points | kanuka/Aga aus/ Cya dea/Vit luc | 44,83&42 | 671,772 &1365 | — | ⩾10 | 40 | — |
| Hen I (D.J. Court 1978 & A.J. Court 1985) | Plot 3x(10x10) | kanuka/Myr aus | 31.5 | — | 1967 | ⩾5 | 140 | 7-8 |
| | | kanuka/Met exc | 31.5 | — | 2233 | ⩾5 | 15 | 14 |

[1] Abbrevations are the first 3 letters of generic and specific names.
[2] PCQ = point centred quarter sampling.

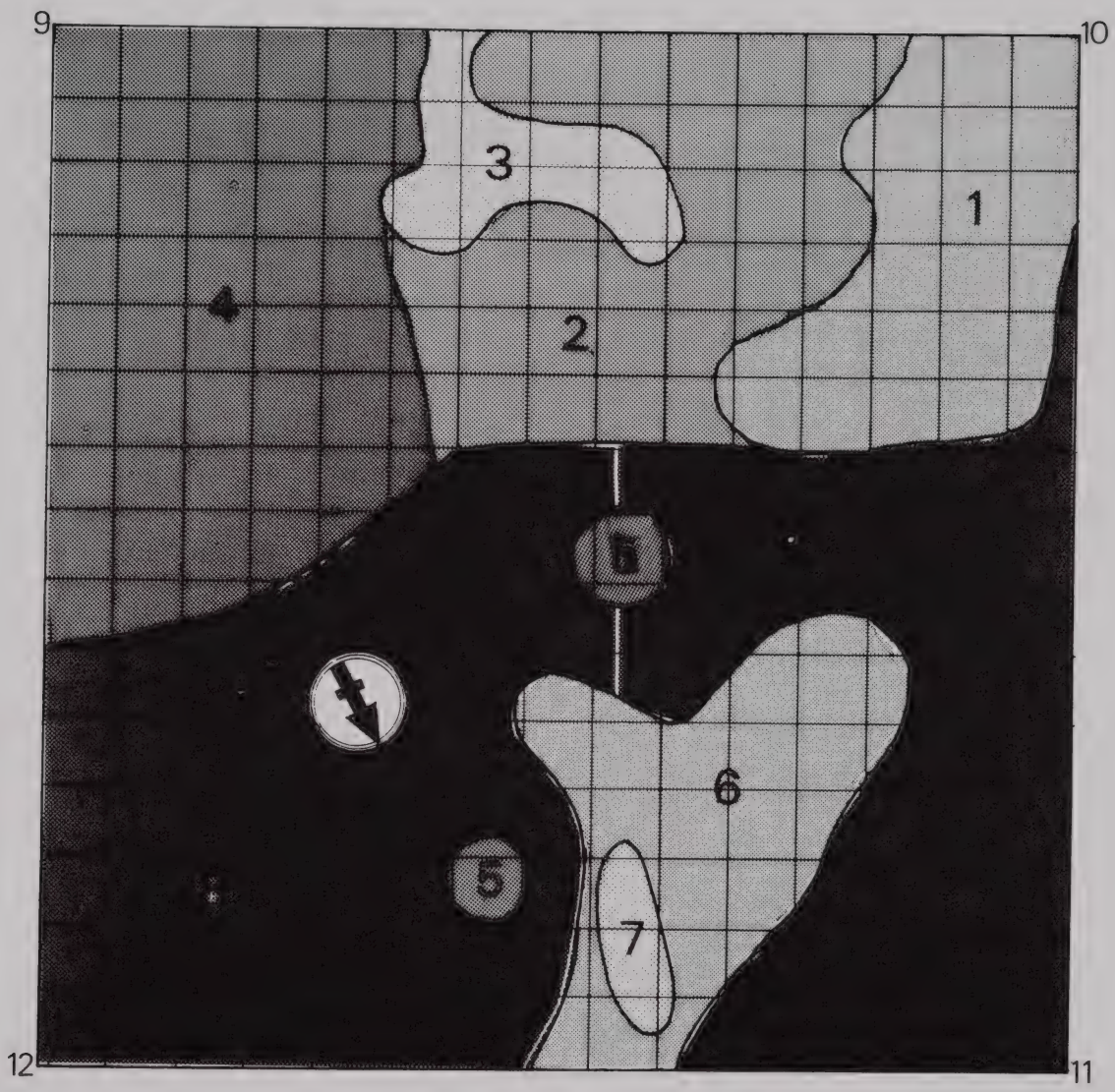


Fig. 5. Quadrat III, December 1982. Increasing density of shading corresponds with a general increase in height of the plant cover. Numbers 1-8 refer to visually different areas of the Quadrat referred to inthe text. Numbers 9-12 correspond with the standard corner numbering system of Holdsworth & Baylis (1967).

The unsuccessful attempt of these two species to establish indicates that their dispersal over the island was by 1963 beginning to probe marginal habitats.

Thirty-six years of vegetation regeneration since the removal of goats has resulted in dramatic recovery of the plant cover of the area around Quadrat III. Comparison of published photographs clearly illustrates this. Figure 14 of Turbott (1948) shows the quadrat on 28 April 1946. The area was dominated by a close-cropped sward of the

native grass *Zoysia pauciflora*. Scattered clumps of *Scirpus nodosus* and parts of two clumps of kanuka were the only contrast. Less than two years later, Baylis re-photographed the quadrat (Turbott 1948 fig.19). The removal of grazing pressure had allowed maturation of the sward, and abundant seed heads were present on the grasses. Invasion of the grassland by kanuka seedlings had begun (Holdsworth 1951).

By 1951 (Holdsworth 1951 fig.16), the *Zoysia*, though still present, had been overtopped by a sward of mixed grasses — *Dichelachne, Aira, Vulpia* and *Rytidosperma. Scirpus nodosus* provided much the same percentage cover, but had been visually overtaken by young kanuka which covered almost 25% of the plot. *Coprosma rhamnoides* was recorded for the first time.

By 1963 (Holdsworth & Baylis 1967 pl.35a), the original dominant, *Zoysia*, had completely disappeared. Kanuka occupied over 80% of the plot, with miniature *Coprosma rhamnoides* beneath it. Species diversity in the remaining grassy areas had dropped, although the total number of species recorded in the quadrat was higher than in previous surveys.

By 1982 (Fig.6) the shrub canopy was found to have diversified by the addition of *Coprosma rhamnoides* in the 0.5-1.5 m height range, and the *Coprosma* together with kanuka occupied over 95% of the quadrat. The tallest kanuka were over 2 m high. Visual inspection of the plot suggested that grasses and herbs had further declined, although the total number of species recorded shows a slight increase since 1963 (Table 2).

Comparison of Fig.7 with that of Holdsworth (1951 fig.6), shows the contrast between 1948 and 1982 quadrat vegetation from a different angle.

Table 2 indicates that species diversity, which increased markedly beteween 1946 and 1963, has begun to level out. This is to be expected as the kanuka/*Coprosma* canopy spreads and reduces the grassy areas in which the greatest species diversity occurs. Appendix 3 shows that Area 8 — the most mature kanuka/*Coprosma* stands which cover nearly 50% of the quadrat area — yielded only 8 species, while Area 1 — low grass, herb and shrubfield which occupies less than 10% of the quadrat — yielded 27 species.

As predicted by previous workers, the vegetation of this part of the island appears to be steadily developing into kanuka forest with a *Coprosma rhamnoides* shrub layer and sparse groundcover that is so common in drier areas of Great I.

## FOREST REGENERATION ON GREAT ISLAND

As mentioned by Holdsworth & Baylis (1967), Quadrats I and II are not typical of the dry kanuka forests with its *Coprosma rhamnoides* understorey which is the most widespread vegetation type on the island.